Standardization of a solution of sodium hydroxide and its use in the calculation of the ethanoic acid concentration in vinegar

AIM
1.To standardize a solution of sodium hydroxide
2. To use this solution to determine the concentration of ethanoic acid in vinegar

INTRODUCTION
Titration is often used to find the exact concentration of a solution, in a process known as **standardization.** It involves reacting a carefully measured volume of the solution whose concentration is not known, with another solution whose concentration is known exactly, known as the **standard solution**. By titration we can determine the exact volumes of the two solutions needed to react together to achieve the equivalence point. From these data and the stoichiometric ratio of the neutralization reaction, the concentration of the solution of unknown concentration can be determined.

In the first part of this experiment, a standard solution of HCl of concentration 0.10 mol dm^{-3} is used to standardize a solution of NaOH. The indicator used to determine the equivalence point is phenolphthalein.

In the second part of this experiment, the standardized solution of NaOH is used in titration against vinegar. From the results the concentration of ethanoic acid in vinegar can be determined.

Pre-lab questions:
> ➢ Write the equation for the neutralization reaction of NaOH and HCl. From this state the reacting ratio of acid and alkali.

> ➢ Write the equation for the neutralization reaction of NaOH and ethanoic acid, CH_3COOH. From this state the reacting ratio of acid and alkali.

> ➢ What colour change do you expect phenolphthalein to undergo at its end point, starting from acid solution?

Part 1 - **Standardization of NaOH**

METHOD

1. Fill a burette with the solution of NaOH(aq) of unknown concentration.
2. Pipette 25.00 cm^3 of the standard solution of 0.10 mol dm^{-3} HCl(aq) onto a clean conical flask.
3. Add a few drops of the indicator phenolphthalein solution to the conical flask and stand it on a white tile or white paper.
4. Titrate the NaOH against the HCl, until the end point of the indicator is observed, and record the volume added from the burette.
5. Repeat the titration until final values within 0.05 cm^3 are obtained.

RESULTS

volume NaOH	titration 1	titration 2	titration 3
end volume /cm^3 $\pm$ 0.05			
start volume /cm^3 $\pm$ 0.05			
titre / cm^3 $\pm$ 0.10			
average titre / cm^3 $\pm$ 0.10	--------		

Record your qualitative data.

ANALYSIS
- Calculate the number of moles of HCl that reacted.
- By reference to the reacting ratio of HCl and NaOH, deduce the number of moles of NaOH required to reach equivalence.
- Calculate the concentration of NaOH in the solution provided.

Part 2 - Titration of sodium hydroxide and vinegar

METHOD
1. Fill a burette with the solution of NaOH(aq) standardized in part 1.
2. Pipette 5.00 cm^3 of vinegar onto a clean conical flask.
Add a few drops of the indicator phenolphthalein solution to the conical flask and stand it on a white tile or white paper.
3. Titrate the NaOH against the vinegar, until the end point of the indicator is observed, and record the volume added from the burette.
4. Repeat the titration until values within 0.05 cm^3 are obtained.

RESULTS

volume NaOH	titration 1	titration 2	titration 3
end volume /cm^3 $\pm$ 0.05			

start volume /cm^3 ± 0.05			
titre / cm^3 ± 0.10			
average titre / cm^3 ± 0.10	--------		

Record your qualitative data.

ANALYSIS
- Calculate the number of moles of NaOH required to reach equivalence.
- By reference to the reacting ratio of NaOH and CH$_3$COOH, deduce the number of moles of CH$_3$COOH required to reach equivalence.
- Calculate the concentration of CH$_3$COOH in the vinegar.

CONCLUSION and EVALUATION
- Compare your result with the data given for ethanoic acid content on the product label, and calculate the percentage difference.
- What assumptions are you making in these calculations?
- Consider the sources of error in your experiment and how you could modify the process to lessen their effect.

For consideration:
1.Why is vinegar sometimes used to remove 'scale' (which is calcium carbonate) from kettles? Write an equation for the reaction that occurs.
2. Some brands of vinegar are coloured solutions. Suggest how may this affect the usefulness of indicators to determine the equivalence point in titration, and what other technique could be used.
3. How could you modify the experiment to determine the pK$_a$ of ethanoic acid?

Equipment list

Chemicals / materials
Non-standardized solution of NaOH - approximately 0.10 mol dm^{-3}
0.10 mol dm^{-3} standardized solution of HCl
Vinegar (preferably light coloured)
Phenolphthalein solution

Apparatus (per group of students)
Burette
25 cm^3 pipette
5 cm^3 pipette
Pipette filler
White tile
Conical flask